Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology and Intel® 852GME and 852PM Chipset Performance Brief

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Executive Summary:

The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology and Intel 852GME & 852PM Chipsets

The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology offers several innovative features for high performance, and is based on the Intel NetBurst™ micro-architecture. End users in the portability segment value desktop-like features such as large screen and keyboard, multiple drives and occasionally move their notebook from place-to-place. The notebooks are connected either to a power source and/or wired network. Notebook form factor, battery life and the freedom to connect wirelessly are not as critical for users in this segment. The Mobile Intel Pentium 4 Processor is designed to deliver performance across applications and usage models where desktop replacement PC users can truly appreciate and experience performance. For example, these applications include Internet audio and video streaming, digital image processing, digital video content creation, speech recognition, 3D graphics, CAD, multimedia, and multitasking user environments. The Mobile Intel Pentium 4 Processor delivers great performance for consumer enthusiasts. With all the performance needed to maximize both current and future Web technologies, as well as being designed to maximize investment protection, the Mobile Intel Pentium 4 processor supporting Hyper-Threading on 90nm technology will continue to deliver great performance for desktop replacement PC users well into the future.

The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology at 2.80 GHz, 3.06 GHz ,3.20 GHz and 3.33 GHz allows a single, physical processor to function as two logical processors. While some execution resources such as caches, execution units, and buses are shared, each logical processor has its own architecture state with its own set of general-purpose registers, control registers to provide increased system responsiveness in multitasking environments, and headroom for next generation multithreaded applications. Intel recommends enabling Hyper-Threading Technology with Microsoft Windows* XP Professional or Windows* XP Home, and disabling Hyper-Threading Technology via the BIOS for all previous versions of Windows operating systems. For more information on Hyper-Threading Technology, see http://www.intel.com/info/hyperthreading.

The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology at 2.80GHz, 3.06GHz, 3.20GHz and 3.33GHz enables high performance through the innovative NetBurst micro-architecture-including Hyper Pipelined Technology, 533 MHz System Bus, 1M L2 cache, Execution Trace Cache, and Rapid Execution Engine-in addition to a number of enhanced features-including the Advanced Transfer Cache, Advanced Dynamic Execution, Enhanced Floating-point and Multimedia units, and Streaming SIMD Extensions 2 (SSE2)-which provide a powerful combination to meet the higher performance and data bandwidth needs for today's and tomorrow's computing environment. These features are offered in FCPGA2 (Flip Chip Pin Grid Array) package form factor. The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology provides for lower thermals along with Intel design guidelines and testing, enabling improved system performance. The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm features Enhanced Intel SpeedStep® Technology support, and a very low power state called Deeper Sleep which operates at a very low voltage. This greatly reduces processor power in the idle state, resulting in improved battery life.

The processor will feature Enhanced Intel SpeedStep® technology, which will enable real-time dynamic switching between multiple voltage and operating frequency points. This results in optimal performance

without compromising low power. The processor features the Auto Halt, Stop Grant, Deep Sleep, and Deeper Sleep low power states.

The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology provides performance for the Visual Internet and is fully compatible and binary compatible with previous Intel Architecture processors. The product will clearly deliver high performance on basic everyday usages; however, the product is designed for much more interactive, highly integrative usage models such as collaborative workgroups, Internet audio and streaming video, image processing, video content creation, speech, 3D, games, multimedia and multitasking user environments. The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology offers great performance for today's and tomorrow's applications.

The Intel 852GME and 852PM Chipset implements the next step in the evolution of the Intel Hub Architecture and was designed in tandem with the Mobile Intel Pentium 4 Processor. The Intel 852PM Chipset was designed to increase performance and enhance the notebook PC user experience both on and off the Internet. Features such as a 533 MHz system bus offer a peak bandwidth of 4.3 GB/s, supports a single Double Data Rate (DDR) memory channel which offers a peak bandwidth of 2.67 GB/s, and the AGP 4X interface allows graphics controllers to access main memory at over 1 GB/s. Intel Hub Architecture delivers twice the I/O bandwidth as previous generation northbridge/southbridge technology. With dedicated data paths to fully optimize the additional bandwidth, the Intel 852PM & 852GME Chipsets deliver high performance and support for future Intel NetBurst micro-architecture-based processors. The Intel 852PM and 852GME Chipsets offer a great combination of compatibility, affordability, and performance for the demands of high-performance based notebook PCs.

This performance brief introduces the Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology, explains the technologies that make it work, examines the purpose and methods behind the industry's most useful benchmarks, and shows how the Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology currently performs on each of the respective benchmarks.

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1. Introduction

The Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology is a follow on to the Mobile Intel Pentium 4 processor on 130-nm process technology in the 478-pin package with enhancements to the Intel NetBurst® microarchitecture. The processor utilizes Flip-Chip Pin Grid Array (FCPGA) package technology, and plugs into a zero insertion force (ZIF) socket. The Mobile Intel Pentium 4 processor supporting Hyper-Threading Technology on 90-nm process technology , like its predecessor, the Mobile Intel Pentium 4 processor in the 478-pin package, is based on the same Intel 32-bit microarchitecture and maintains the tradition of compatibility with IA-32 software. In this document the Mobile Intel Pentium 4 processor supporting Hyper-Threading Technology on 90-nm process technology will be referred to as the "the processor."

The Mobile Intel® Pentium® 4 Processor on 90-nm process technology supports Hyper-Threading Technology. Hyper-Threading Technology allows a single, physical processor to function as two logical processors. While some execution resources such as caches, execution units, and buses are shared, each logical processor has its own architecture state with its own set of general-purpose registers, control registers to provide increased system responsiveness in multitasking environments, and headroom for next generation multi threaded applications. Intel recommends enabling Hyper-Threading Technology with Microsoft Windows* XP Professional or Windows*XP Home, and disabling Hyper-Threading Technology via the BIOS for all previous versions of Windows operating systems. For more information on Hyper-Threading Technology, see www.intel.com/info/hyperthreading. Refer to Section 6.1 for Hyper-Threading Technology configuration details.

In addition to supporting all the existing Streaming SIMD Extensions 2 (SSE2), there are 13 new instructions, which further extend the capabilities of Intel processor technology. These new instructions are called Streaming SIMD Extensions 3 (SSE3).These new instructions enhance the performance of optimized applications for the digital home such as video, image processing and media compression technology. 3D graphics and other entertainment applications such as gaming will take advantage of these new instructions as platforms with the Mobile Intel Pentium 4 processor supporting Hyper-Threading Technology on 90-nm process technology and SSE3 become available in the market place.

The processor’s Intel NetBurst microarchitecture front side bus (FSB) utilizes a split-transaction, deferred reply protocol like the previous Mobile Intel Pentium 4 processor. The Intel NetBurst microarchitecture front side bus uses Source-Synchronous Transfer (SST) of address and data to improve performance by transferring data four times per bus clock (4X data transfer rate, as in AGP 4X). Along with the 4X data bus, the address bus can deliver addresses two times per bus clock and is referred to as a "double-clocked" or 2X address bus. Working together, the 4X data bus and 2X address bus provide a data bus bandwidth of up to 4.3 GB/s.

The processor will feature Enhanced Intel SpeedStep® technology, which will enable real-time dynamic switching between multiple voltage and operating frequency points. This results in optimal performance without compromising low power. The processor features the Auto Halt, Stop Grant, Deep Sleep, and Deeper Sleep low power states.

The processor includes an address bus power down capability which removes power from the address and data pins when the FSB is not in use. This feature is always enabled on the processor.

2. The Mobile Intel® Pentium® 4 Processor on 90nm technology supporting Hyper-Threading

The Mobile Intel® Pentium® 4 Processor on 90nm technology supporting Hyper-Threading is based on the Intel NetBurst micro-architecture. The Mobile Intel® Pentium® 4 Processor on 90nm technology supporting Hyper-Threading is designed to deliver performance across applications and usages where end users can truly appreciate and experience the performance. These applications include Internet audio and streaming video, image processing, video content creation, speech, 3D, multimedia, and multitasking user environments. The Mobile Intel® Pentium® 4 Processor on 90nm technology supporting Hyper-Threading delivers this great performance for consumer enthusiast notebook PC users.

Highlights of the Mobile Intel Pentium 4 Processor:

- Support for Hyper-Threading Technology offered at 2.80GHz, 3.06 GHz, 3.20GHz and 3.33 GHz
- Features the Intel NetBurst micro-architecture
- Supported by the Intel® 852GME and 852PM chipsets
- Fully compatible with existing Intel Architecture-based software
- Streaming SIMD Extensions 3
- Source-Synchronous Transfer (SST)
- Intel MMX™ media enhancement technology
- Memory cache ability up to 4 GB of addressable memory space and system memory scalability up to 64 GB of physical memory
- Based upon Intel's advanced 90nm manufacturing process
- Power Management Capabilities: Auto Halt, Stop Grant, Sleep, Deep Sleep, and Deeper Sleep.

3. Mobile Intel® Pentium® 4 Processor supporting Hyper-Threading on 90nm technology Product Feature Highlights

The Intel NetBurst micro-architecture features include hyper-pipelined technology, a rapid execution engine, a 533-MHz system bus, and an execution trace cache. The hyper pipelined technology doubles the pipeline depth in the Mobile Intel Pentium 4 Processor allowing the processor to reach much higher core frequencies. The rapid execution engine allows the two integer ALUs in the processor to run at twice the core frequency, which allows many integer instructions to execute in 1/2 clock tick. The 533-MHz system bus is a quad-pumped bus running off a 133-MHz system clock making 4.3 GB/sec data transfer rates possible. The execution trace cache is a first level cache that stores approximately 12K decoded micro-operations, which removes the instruction decoding logic from the main execution path, thereby increasing performance. The features and resulting benefits of the micro-architecture are defined below.

- Hyper-Threading Technology Support
  The Mobile Intel® Pentium® 4 Processor on 90nm technology at 2.80 GHz, 3.06 GHz, 3.20 GHz and 3.33GHz support Hyper-Threading Technology, which allows a single, physical processor to function as two logical processors. While some execution resources such as caches, execution units, and buses are shared, each logical processor has its own architecture state with its own set of general-purpose registers, control registers to provide increased system responsiveness in multitasking environments, and headroom for next generation multithreaded applications.

- Low Power States and Enhanced Intel SpeedStep Technology Support
  The Mobile Intel Pentium 4 Processor features the Stop Grant, Sleep, Deep Sleep, and Deeper Sleep low power states and is offered 2.80 GHz, 3.06 GHz, 3.20 GHz and 3.33 GHz with Enhanced Intel SpeedStep Technology support. Highlights of this technology include:

  - Real-time dynamic switching between multiple voltage and operating frequency points. This results in optimal performance without compromising low power. The processor features the Auto Halt, Stop Grant, Deep Sleep, and Deeper Sleep low power states.

- 533 MHz System Bus
  The Mobile Intel Pentium 4 Processor supports a high performance mobile system bus by delivering 4.3GB of data per second into and out of the processor. This is accomplished through a physical signaling scheme of quad pumping the data transfers over a 133-MHz clocked system bus and a buffering scheme allowing for sustained 533-MHz data transfers.

- 1M Level 2 Advanced Transfer Cache
  The Level 2 Advanced Transfer Cache (ATC) is 1M, Double the size of previous Mobile Intel Pentium 4 and delivers a much higher data throughput channel between the Level 2 cache and the processor core. The Advanced Transfer Cache transfers data on each core clock. Features of the ATC include:

- Non-Blocking, full speed, on-die Level 2 cache
- 8-way set associativity
- Data clocked into and out of the cache every clock cycle

- Enhanced Floating-Point and Multimedia Unit
  The Mobile Intel Pentium 4 Processor expands the floating-point registers to a full 128-bit and adds an additional register for data movement which improves performance on both floating-point and multimedia applications.

- Streaming SIMD Extensions 2 (SSE2)
  The Streaming SIMD Extensions 2 (SSE2) enable break-through levels of performance in multimedia applications including 3-D graphics, video decoding/encoding, and speech recognition. The new packed, double-precision, floating-point instructions enhance performance for applications that require greater range and precision, including scientific and engineering applications and advanced 3-D geometry techniques, such as ray tracing.

- Streaming SIMD Extensions 3 (SSE3)
  The Streaming SIMD Extensions 3 (SSE3) has 13 new instructions over previous SSE2. These new instructions enhance the performance of optimized applications for the digital home such as video, image processing and media compression technology. 3D graphics and other entertainment applications such as gaming will take advantage of these new instructions as platforms with the Mobile Intel Pentium 4 processor supporting Hyper-Threading Technology on 90-nm process technology and SSE3 become available in the market place.

- Features Used for Test and Performance / Thermal Monitoring:
  - Built-in Self Test (BIST) provides single stuck-at fault coverage of the microcode and large logic arrays, as well as testing of the instruction cache, data cache, Translation Lookaside Buffers (TLBs), and ROMs.
  - IEEE 1149.1 Standard Test Access Port and Boundary Scan mechanism enables testing of the Mobile Intel Pentium 4 Processor and system connections through a standard interface.
  - Internal performance counters can be used for performance monitoring and event counting.
  - Includes an on-die thermal diode and a Thermal Monitor feature for thermal management purposes

- 90nm manufacturing technology
  Intel's latest leading edge process technology. Smaller transistors versus previous 130-nano meter technology. Enables higher cpu clock speeds and performance as compared to previous 130-nano meter technology based products.

4. Intel® 852PM and Intel® 852GME Chipset Product Feature Highlights

As the next step in the evolution of the Intel Hub Architecture, the Intel 852PM Chipset was designed to support the Mobile Intel Pentium 4 processor.

The Intel 852PM Memory Controller Hub (MCH) and Intel 852GME Graphics Memory Controller Hub (GMCH) delivers support for either PC2100 or PC2700 DDR memory technology and a 533 MHz Front Side Bus, providing discrete graphics support through 1.5V AGP4X technology. Together these features deliver high total bandwidth capabilities to the notebook PC platform.

In addition, the 852GME GMCH contains a graphics display engine with the following capabilities:

- Digital display support through two DVO ports (165-MHz, 12-bit DVO)
- Integrated 350-MHz, 24-bit RAMDAC with maximum pixel resolution support up to 1600x1200 at 85 Hz and up to 2048x1536 at 75 Hz
- One Dedicated Dual Channel LFP LVDS interface with frequency range of 25 MHz to 112 MHz (single channel/dual channel) for support up to UXGA (1600 x 1200 @ 60 Hz) panel resolutions with maximum pixel depth of 18-bpp

The Intel® 852PM and 852GME chipsets feature the enhanced 82801DBM I/O Controller Hub 4-Mobile (ICH4-M) delivers twice the I/O bandwidth over traditional bridge architecture and provides dedicated data paths to fully optimize the additional bandwidth. The ICH4-M makes a direct connection from the graphics and memory for faster access to peripherals and provides the features and bandwidth required for a high performance notebook.

In addition to advanced application support, the Intel 852PM and 852GME Chipsets are designed with the following feature to enhance the end-user experience:

- 533 MHz system bus delivers a high bandwidth connection between the Mobile Intel Pentium 4 processor and the platform.
- The DDR memory channel can deliver up to 2.67 GB/s of memory bandwidth to the processor. High memory bandwidth, coupled with an efficient protocol, provides the memory bandwidth necessary to extract great performance from the Mobile Intel Pentium 4 processor.
- The AGP4X interface allows graphics controllers to access main memory at over 1 GB/s, twice that of previous AGP platforms.
- Support for Hi-Speed Universal Serial Bus (USB 2.0) with backward compatibility with USB 1.1
- AC’97 2.2 Interface with support for a third codec to provide 20 bit resolution. The latest AC97 audio delivers six channels of audio for enhanced sound quality and full surround sound capability for live broadcast and other Digital Dashboard programming

- LAN Connect Interface (LCI) provides flexible network solutions such as home phone line, 10/100 Mbps Ethernet, and 10/100 Mbps Ethernet with LAN manageability.
- Dual Ultra ATA-100 controllers support the fastest IDE interface for transfers to storage devices
- Support for Hyper-Threading Technology
- Support for ACPI- defined power states C1-C4, S1, S3-S5
- Support for Enhanced Intel SpeedStep Technology
- Support for "Deeper Sleep" power state
- Allows wake-up from sleeping states S1-S4

Designed to balance performance and power in the Mobile Intel Pentium 4 processor the Intel 852PM and 852GME Chipsets deliver a robust foundation for the most sophisticated end-user applications. The 852PM and 852GME Chipsets offer innovative design, high-speed memory, and configuration options that optimize performance and provide a solid base for the Mobile Intel Pentium 4 processor.

5. Performance Summary

Mobile Experience - MobileMark* 2002

MobileMark*2002 evaluates notebook user experience by measuring both performance and battery life at the same time on the same workload. MobileMark 2002 is a tool that measures notebook performance on popular business-oriented applications in the Microsoft* Windows* operating environment. The BAPCo MobileMark 2002 workload consists of two usage models: a productivity usage model and a reader usage model. The BAPCo MobileMark 2002 productivity usage model provides computations representing today's business users using popular office productivity and content creation applications. The productivity usage model reports a performance score and a battery life score.

The productivity workload of BAPCo MobileMark 2002 consists of emerging usage models and popular productivity applications including:

- Adobe* Photoshop* 6.0.1
- Macromedia* Flash* 5.0
- McAfee* VirusScan* 5.13
- Microsoft* Excel* 2002
- Microsoft* Outlook* 2002
- Microsoft* PowerPoint* 2002
- Microsoft* Word* 2002
- Netscape* Communicator* 6.0
- WinZip* 8.0

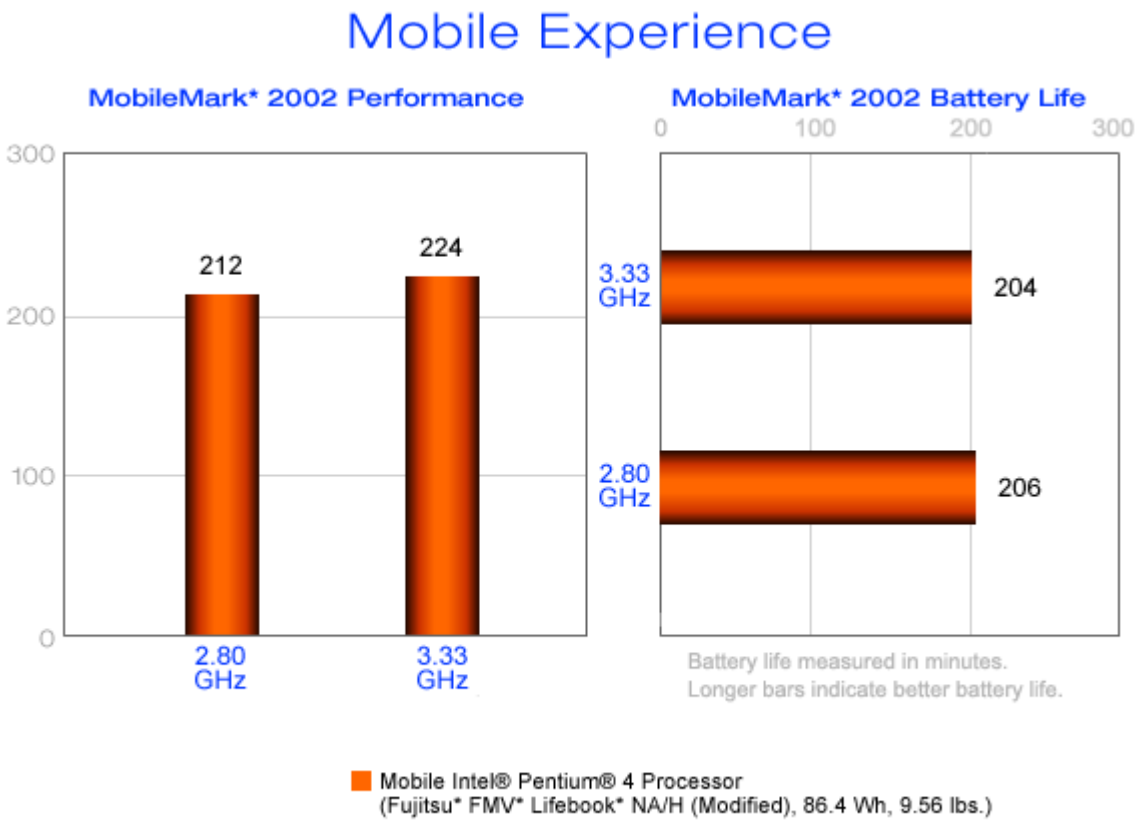

Figure 1. Mobile Intel® Pentium® 4 Processor Performance and Battery Life on MobileMark* 2002

Internet Experience - WebMark* 2004

WebMark* 2004 is BAPCo's latest version of the popular Internet Client benchmark based on the latest web technologies and internet usage models that measures and enables comparison of PC performance based upon Information Processing and Commercial Transactions. Featuring two modes of operation, the Offline mode enables users to measure the Internet client performance of a PC using content stored locally while the On-line mode requires an additional server to host test content.

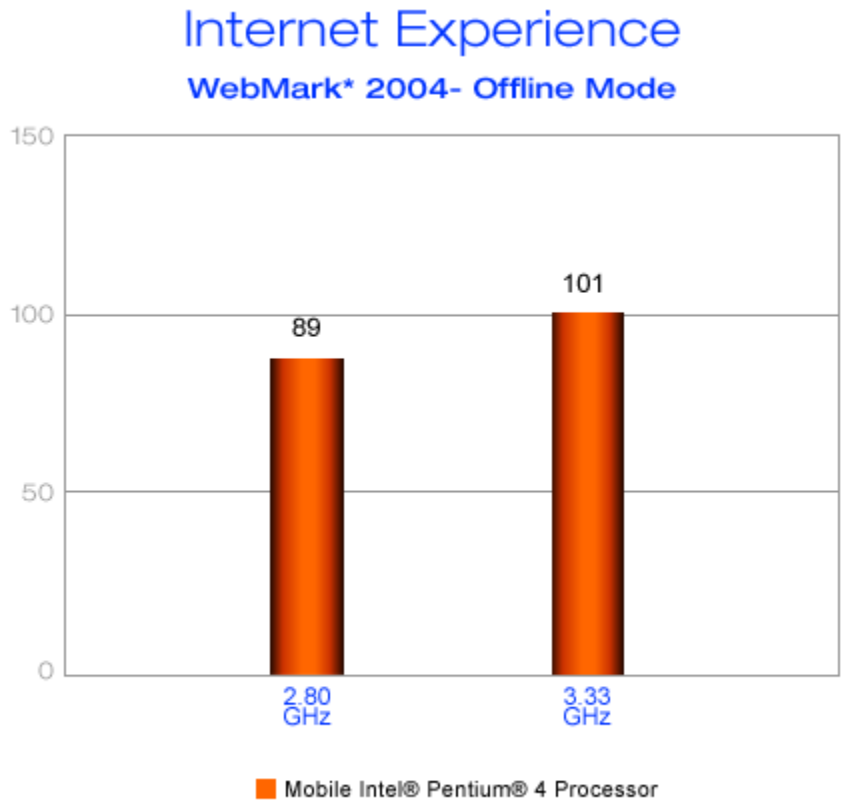

Figure 2. Mobile Intel® Pentium® 4 Processor Performance on WebMark* 2004 – Offline Mode

6. Summary of Results

Table 1 summarizes the benchmark performance of the Mobile Intel Pentium 4 processor 2.80 GHz and 3.33 GHz. A higher score indicates better performance except for time related scores in which less time indicates better performance. All data taken on Windows XP.

Table 1. Raw Performance Data

Benchmark/Application Software	Mobile Intel Pentium 4 Processor 2.80 GHz	Mobile Intel Pentium 4 Processor 3.33 GHz
MobileMark* 2002 – Performance	212	224
MobileMark* 2002 – Battery Life (minutes)	206	204
WebMark* 2004 – Offline Mode	89	101

Table 2 summarizes the benchmark performance of the Mobile Intel Pentium 4 processor 3.06 GHz and 2.66 GHz relative to that of the Mobile Intel Pentium 4 Processor 2.40 GHz. A higher score indicates better performance except for time related scores in which less time indicates better performance. All data taken on Windows XP.

Table 2. Normalized Performance Results

Benchmark/Application Software	Mobile Intel Pentium 4 Processor 2.80 GHz	Mobile Intel Pentium 4 Processor 3.33 GHz
MobileMark* 2002 – Performance	1.00	1.06
MobileMark* 2002 – Battery Life (minutes)	N/A	N/A
WebMark* 2004 – Offline Mode	1.00	1.13

Appendix A: Notebook PC Configuration

Table 4. Notebook PC Configuration Used for Performance Measurement

Processor	Mobile Intel® Pentium® 4 processor 2.80 GHz and 3.33 GHz
Motherboard Chipset	Intel 852GME
Vendor and Model	Fujitsu* FMV* Lifebook* NA/H (Modified)
Motherboard BIOS	Phoenix* Fujitsu* v.1.31
Secondary Cache	1MB Full-Speed On-Die Level 2 Cache
Memory Size	1GB (2x512MB) PC2700 DDR 333 Infineon*
Chipset INF File	Windows*: Intel INF: 4.30.1006
Hard Disk	Hitachi* HTS726060M9AT00 60GB 7200 RPM
Hard Disk Driver	Microsoft* Default 5.1.2535.0
Video Controller	Integrated Intel(R) Extreme Graphics 2
Video Memory Size/Type	64MB Dynamic Video Memory Technology (DVMT)
Video Driver Revision	6.14.10.3691
Operating System	Microsoft Windows* XP Professional, Build 2600, Service Pack 2 on NTFS
System Driver – MS DirectX*	DirectX 9.0b
Graphics	1024x768 resolution, 32-bit color
Sound Card	Realtek* AC97 Audio Driver ver. 5.10.0.5170
Network Card	Broadcom* NetXtreme* Gigabit Driver ver. 7.35.0.0
Battery Capacity	86.4 WHr
Weight	9.56 lbs
Screen Size	15"
Screen Brightness	~30 nits
Power Management Mode for MobileMark* 2002	Portable/laptop